

William Stallings

Data and Computer

Communications

7th Edition

Chapter 10

Circuit Switching and Packet Switching

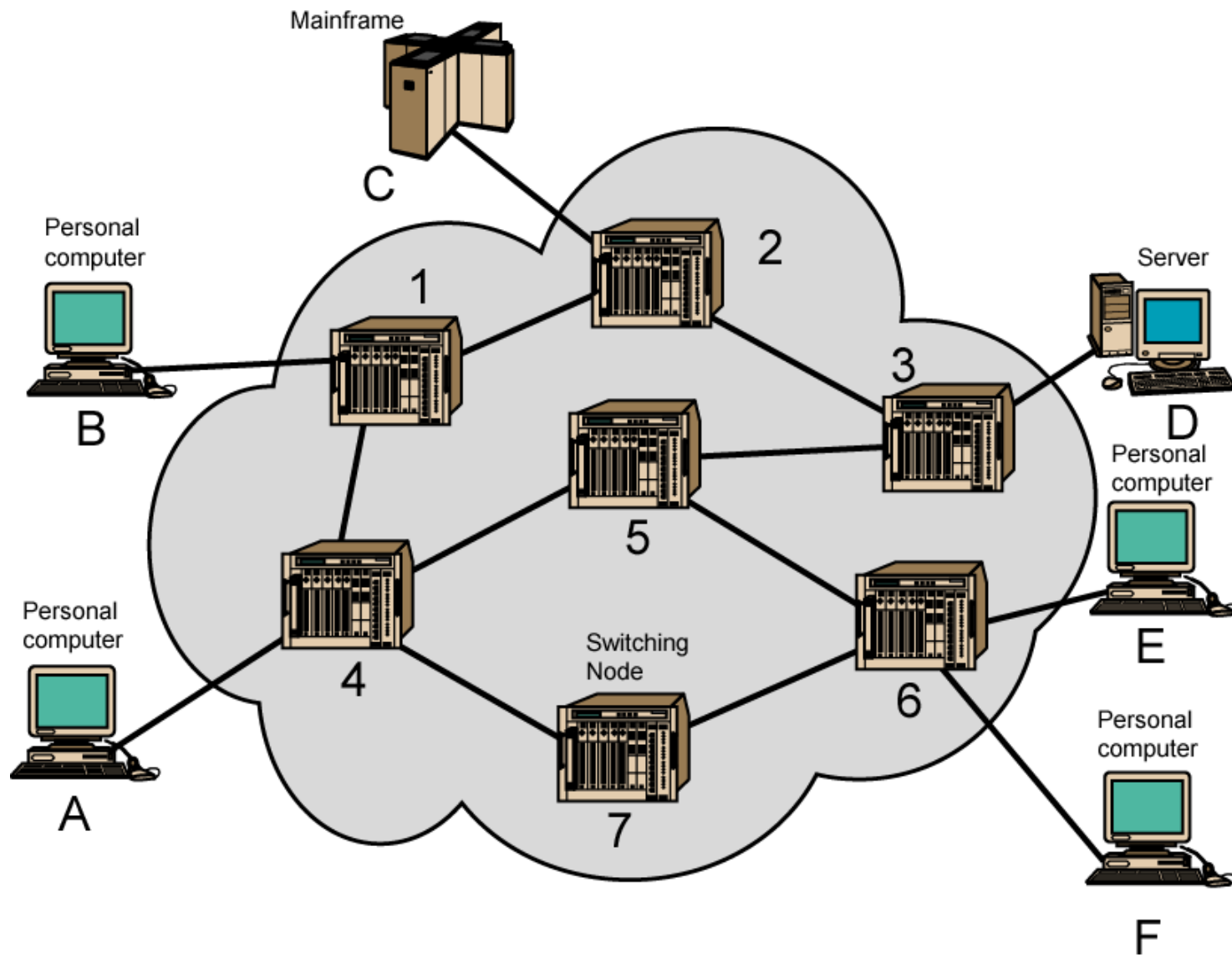
Switching Networks

- Long distance transmission is typically done over a network of switched nodes
- Nodes not concerned with content of data
- End devices are stations
 - Computer, terminal, phone, etc.
- A collection of nodes and connections is a communications network
- Data routed by being switched from node to node

Nodes

- Nodes may connect to other nodes only, or to stations and other nodes
- Node to node links usually multiplexed
- Network is usually partially connected
 - Some redundant connections are desirable for reliability
- Two different switching technologies
 - Circuit switching
 - Packet switching

Simple Switched Network



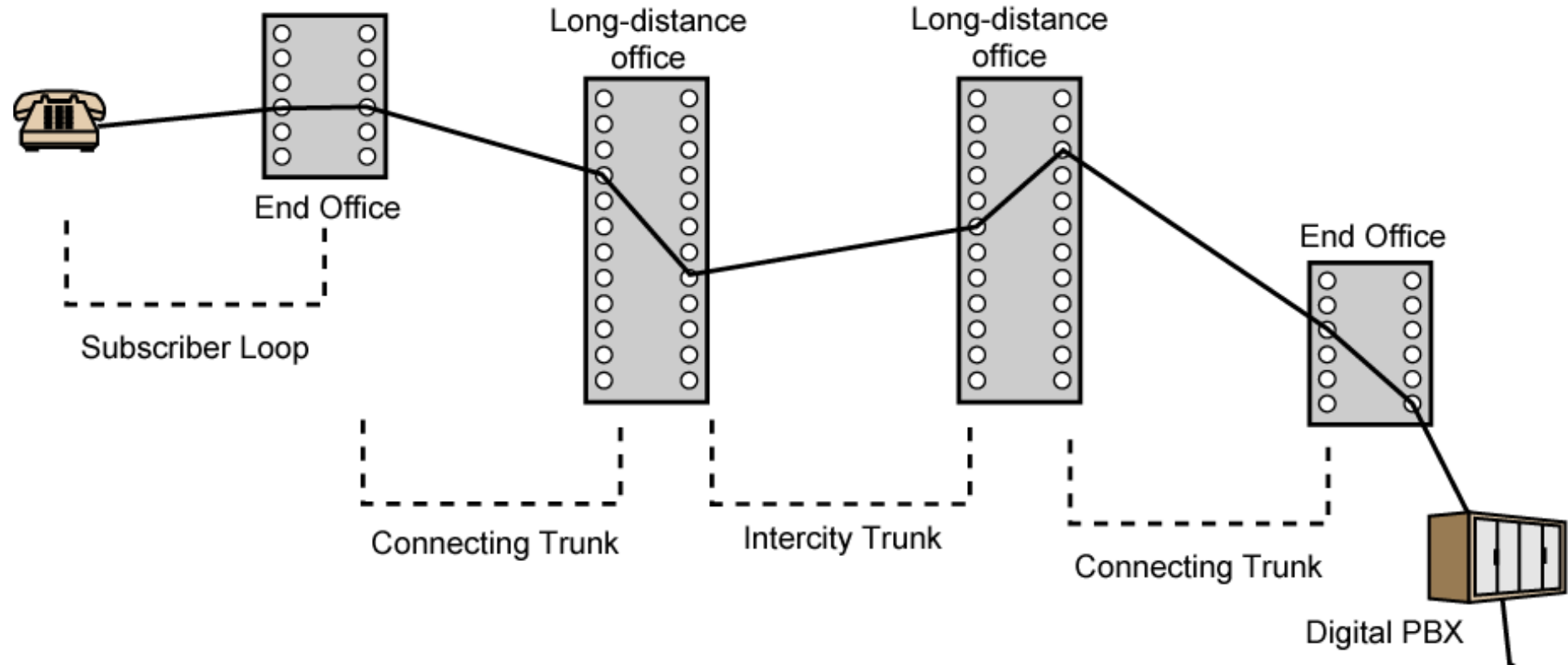
Circuit Switching

- Dedicated communication path between two stations
- Three phases
 - Establish
 - Transfer
 - Disconnect
- Must have switching capacity and channel capacity to establish connection
- Must have intelligence to work out routing

Circuit Switching - Applications

- Inefficient
 - Channel capacity dedicated for duration of connection
 - If no data, capacity wasted
- Set up (connection) takes time
- Once connected, transfer is transparent
- Developed for voice traffic (phone)

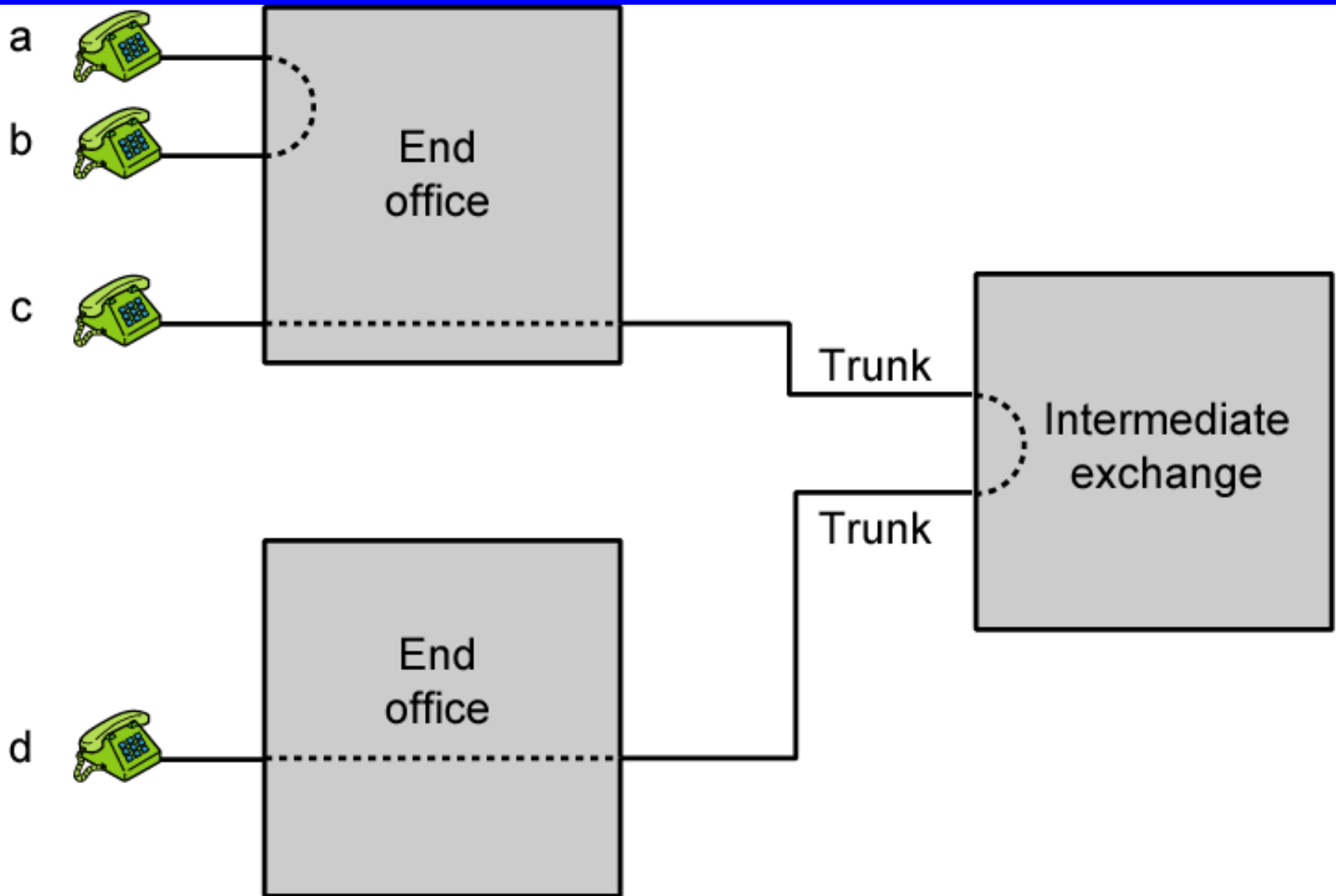
Public Circuit Switched Network



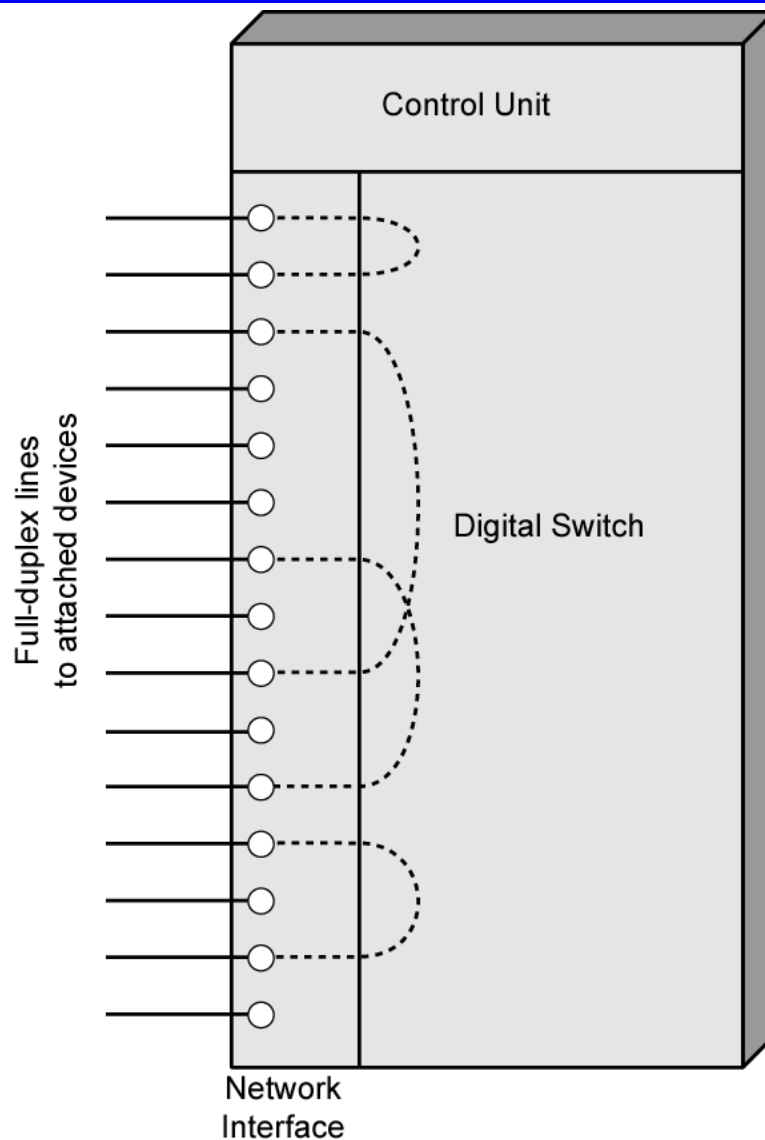
Telecomms Components

- Subscriber
 - Devices attached to network
- Subscriber line
 - Local Loop
 - Subscriber loop
 - Connection to network
 - Few km up to few tens of km
- Exchange
 - Switching centers
 - End office - supports subscribers
- Trunks
 - Branches between exchanges
 - Multiplexed

Circuit Establishment



Circuit Switch Elements



Circuit Switching Concepts

- Digital Switch
 - Provide transparent signal path between devices
- Network Interface
- Control Unit
 - Establish connections
 - Generally on demand
 - Handle and acknowledge requests
 - Determine if destination is free
 - construct path
 - Maintain connection
 - Disconnect

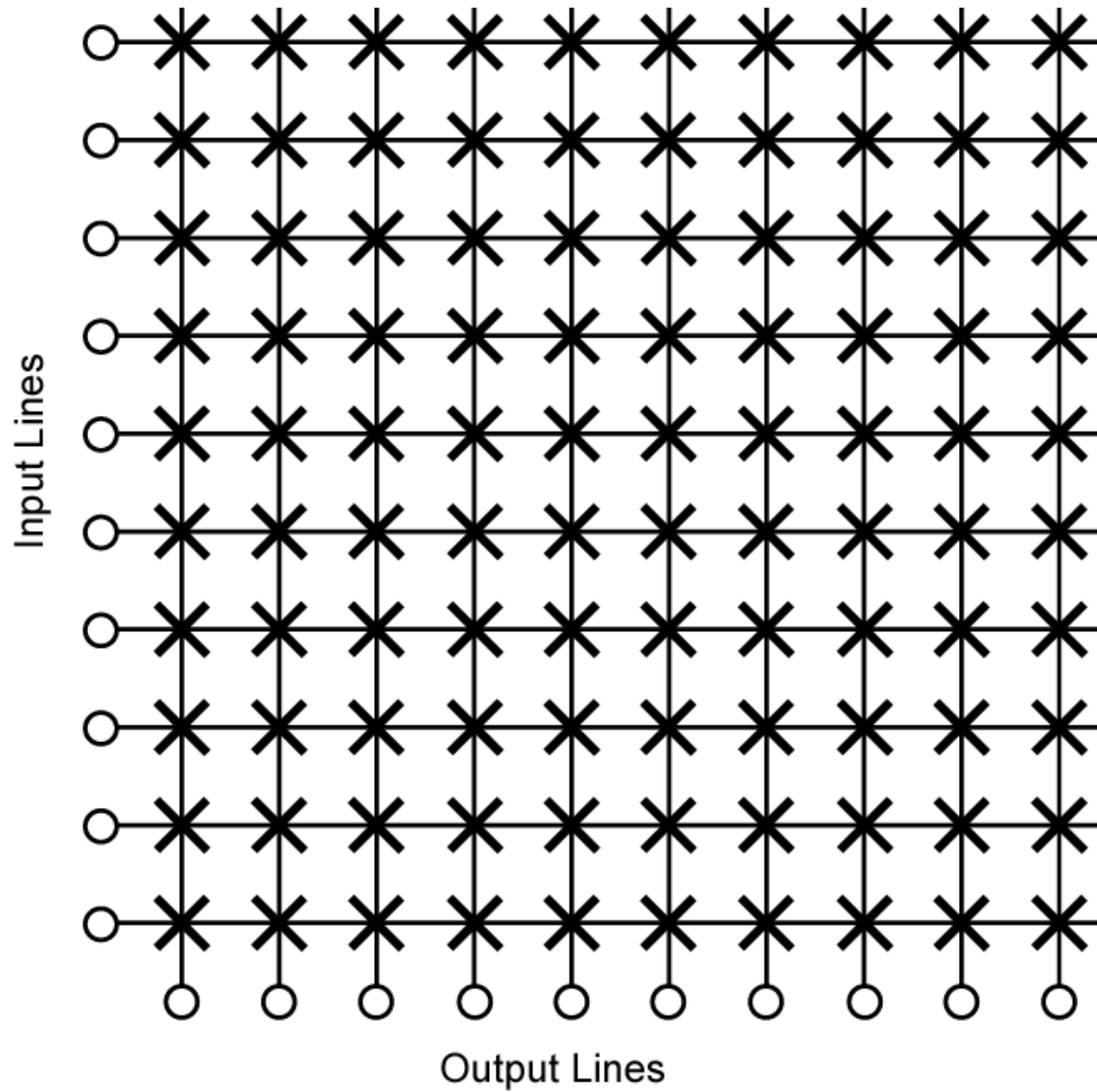
Blocking or Non-blocking

- Blocking
 - A network is unable to connect stations because all paths are in use
 - A blocking network allows this
 - Used on voice systems
 - Short duration calls
- Non-blocking
 - Permits all stations to connect (in pairs) at once
 - Used for some data connections

Space Division Switching

- Developed for analog environment
- Separate physical paths
- Crossbar switch
 - Number of crosspoints grows as square of number of stations
 - Loss of crosspoint prevents connection
 - Inefficient use of crosspoints
 - All stations connected, only a few crosspoints in use
 - Non-blocking

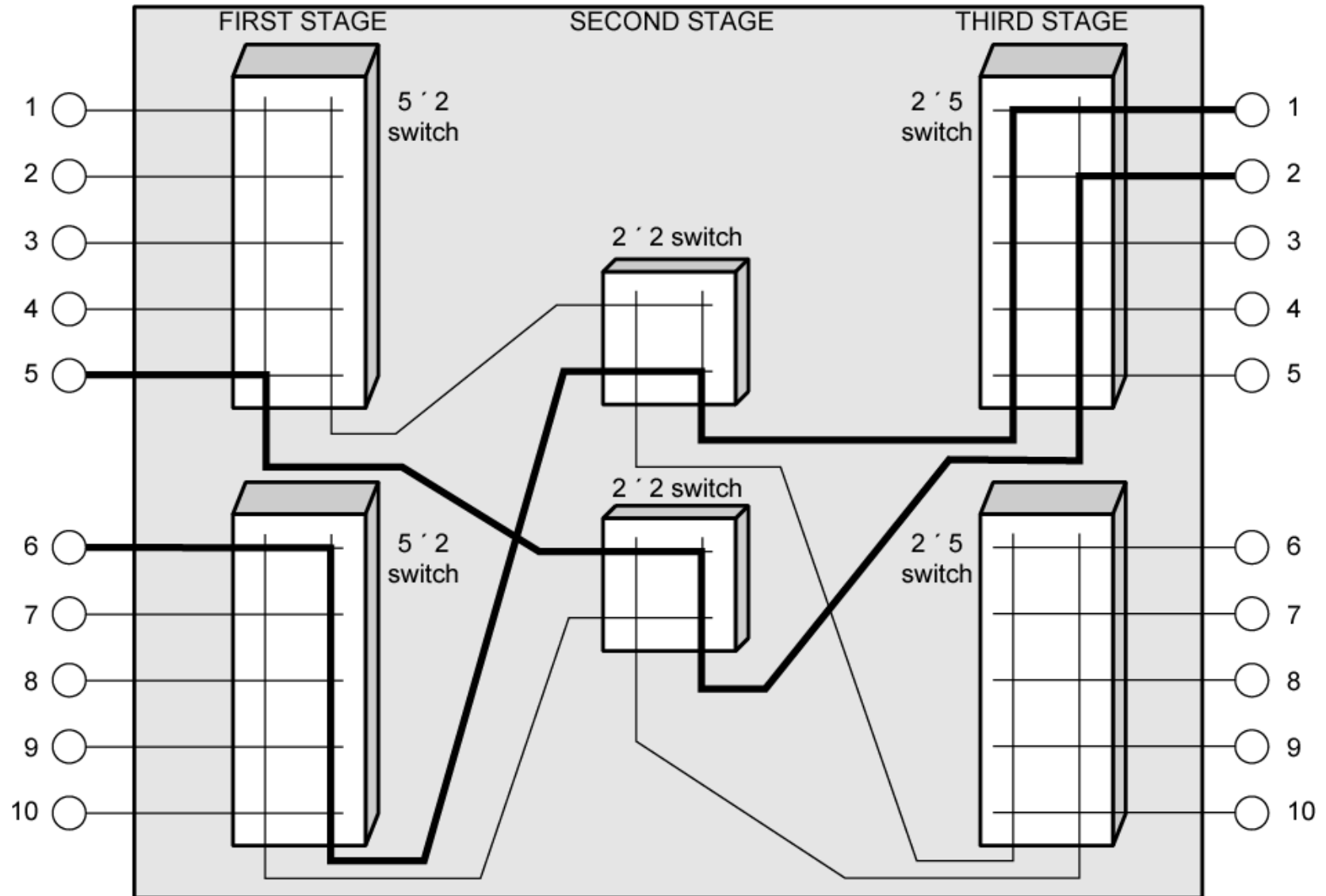
Space Division Switch



Multistage Switch

- Reduced number of crosspoints
- More than one path through network
 - Increased reliability
- More complex control
- May be blocking

Three Stage Space Division Switch



Time Division Switching

- Modern digital systems rely on intelligent control of space and time division elements
- Use digital time division techniques to set up and maintain virtual circuits
- Partition low speed bit stream into pieces that share higher speed stream

Control Signaling Functions

- Audible communication with subscriber
- Transmission of dialed number
- Call can not be completed indication
- Call ended indication
- Signal to ring phone
- Billing info
- Equipment and trunk status info
- Diagnostic info
- Control of specialist equipment

Control Signal Sequence

- Both phones on hook
- Subscriber lifts receiver (off hook)
- End office switch signaled
- Switch responds with dial tone
- Caller dials number
- If target not busy, send ringer signal to target subscriber
- Feedback to caller
 - Ringing tone, engaged tone, unobtainable
- Target accepts call by lifting receiver
- Switch terminates ringing signal and ringing tone
- Switch establishes connection
- Connection release when Source subscriber hangs up

Switch to Switch Signaling

- Subscribers connected to different switches
- Originating switch seizes interswitch trunk
- Send off hook signal on trunk, requesting digit register at target switch (for address)
- Terminating switch sends off hook followed by on hook (wink) to show register ready
- Originating switch sends address

Location of Signaling

- Subscriber to network
 - Depends on subscriber device and switch
- Within network
 - Management of subscriber calls and network
 - ore complex

In Channel Signaling

- Use same channel for signaling and call
 - Requires no additional transmission facilities
- Inband
 - Uses same frequencies as voice signal
 - Can go anywhere a voice signal can
 - Impossible to set up a call on a faulty speech path
- Out of band
 - Voice signals do not use full 4kHz bandwidth
 - Narrow signal band within 4kHz used for control
 - Can be sent whether or not voice signals are present
 - Need extra electronics
 - Slower signal rate (narrow bandwidth)

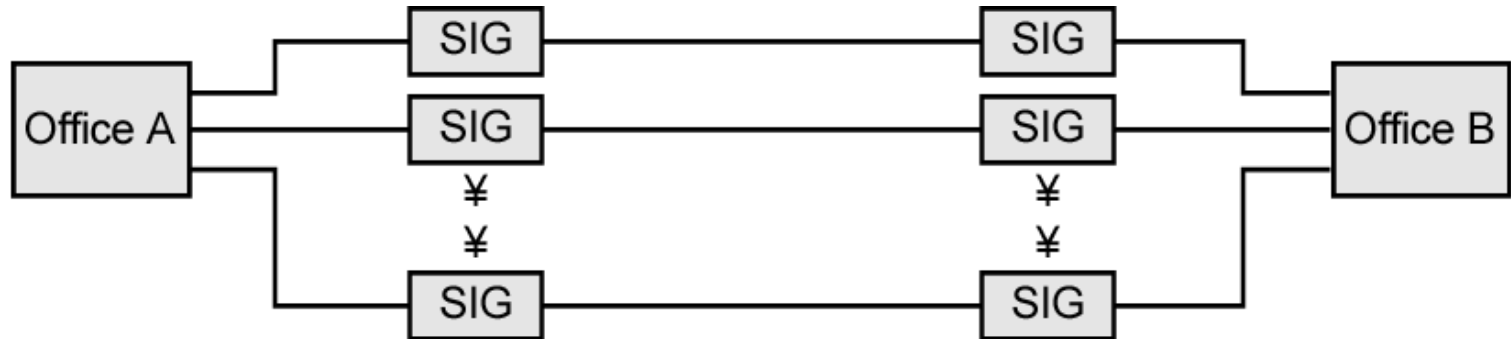
Drawbacks of In Channel Signaling

- Limited transfer rate
- Delay between entering address (dialing) and connection
- Overcome by use of common channel signaling

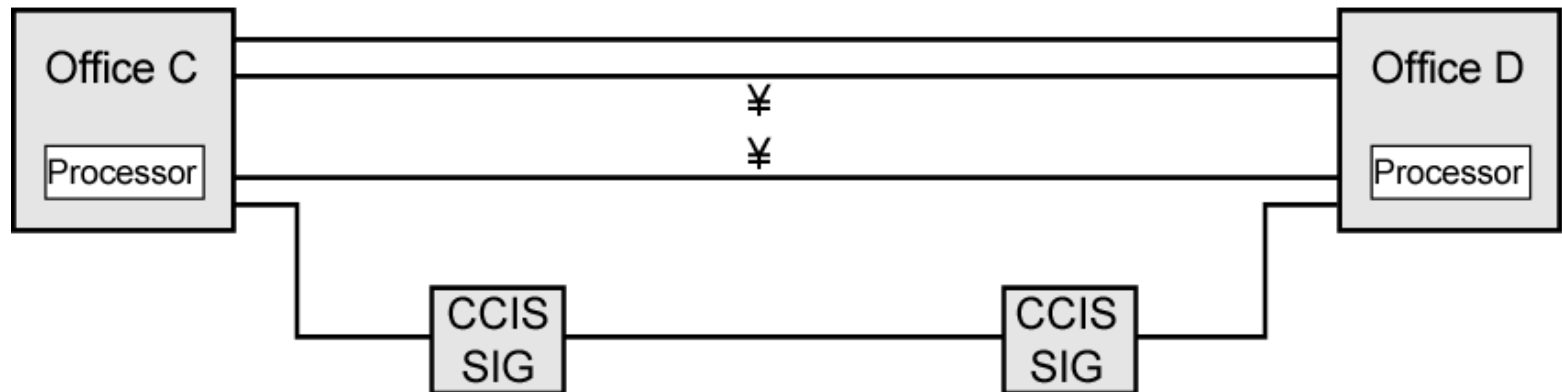
Common Channel Signaling

- Control signals carried over paths independent of voice channel
- One control signal channel can carry signals for a number of subscriber channels
- Common control channel for these subscriber lines
- Associated Mode
 - Common channel closely tracks interswitch trunks
- Disassociated Mode
 - Additional nodes (signal transfer points)
 - Effectively two separate networks

Common v. In Channel Signaling



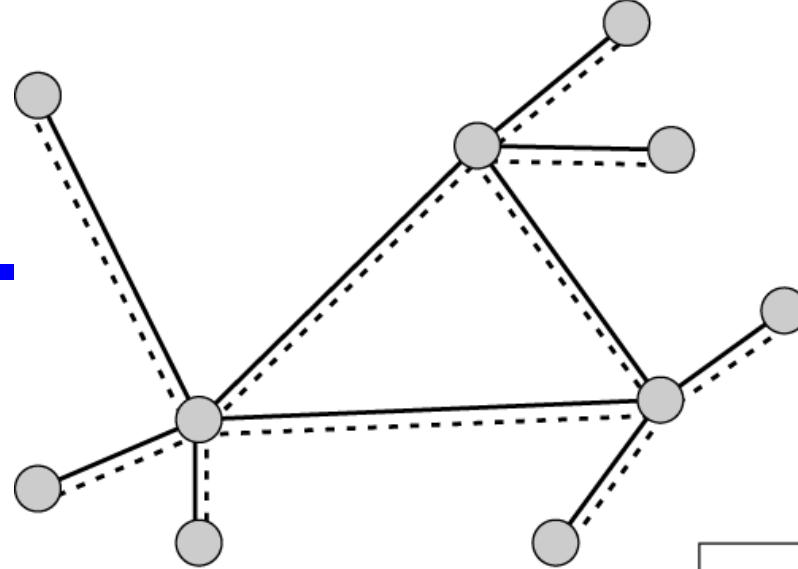
(a) Inchannel



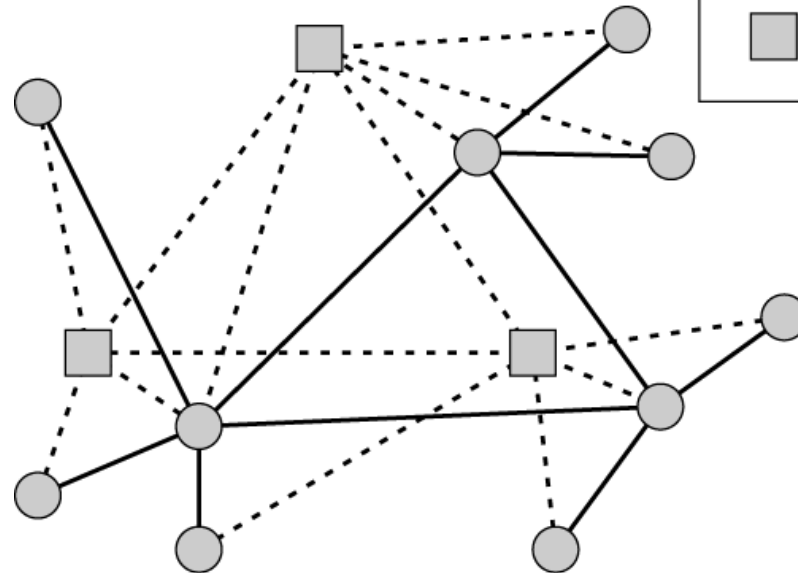
(b) Common channel

CCIS SIG: Common-channel interoffice signaling equipment
SIG: Per-trunk signaling equipment

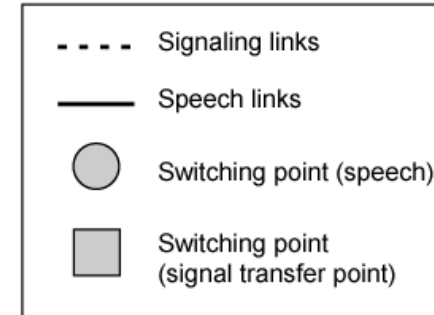
Common Channel Signaling Modes



(a) Associated



(b) Disassociated



Signaling System Number 7

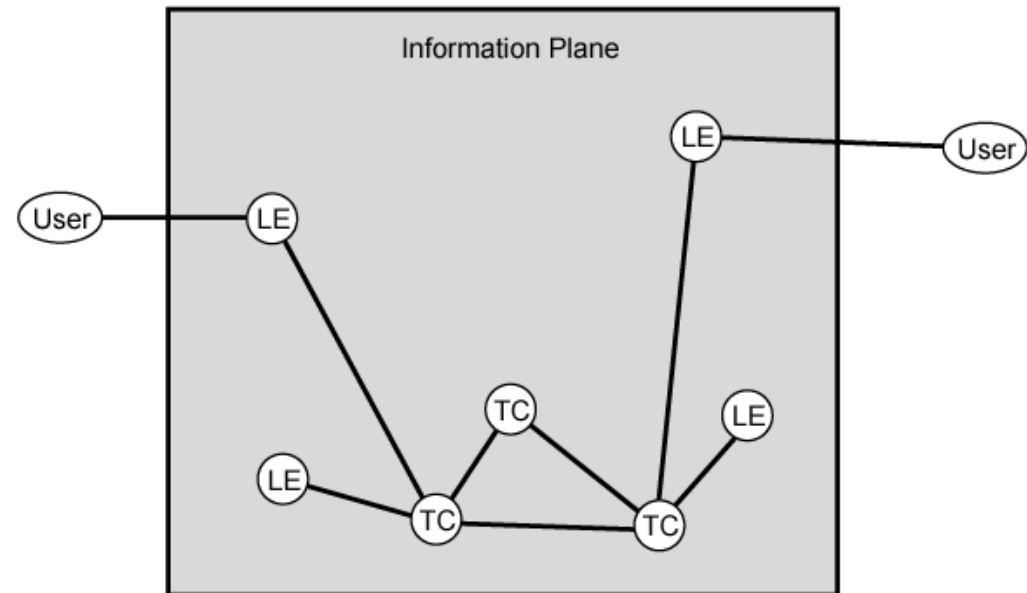
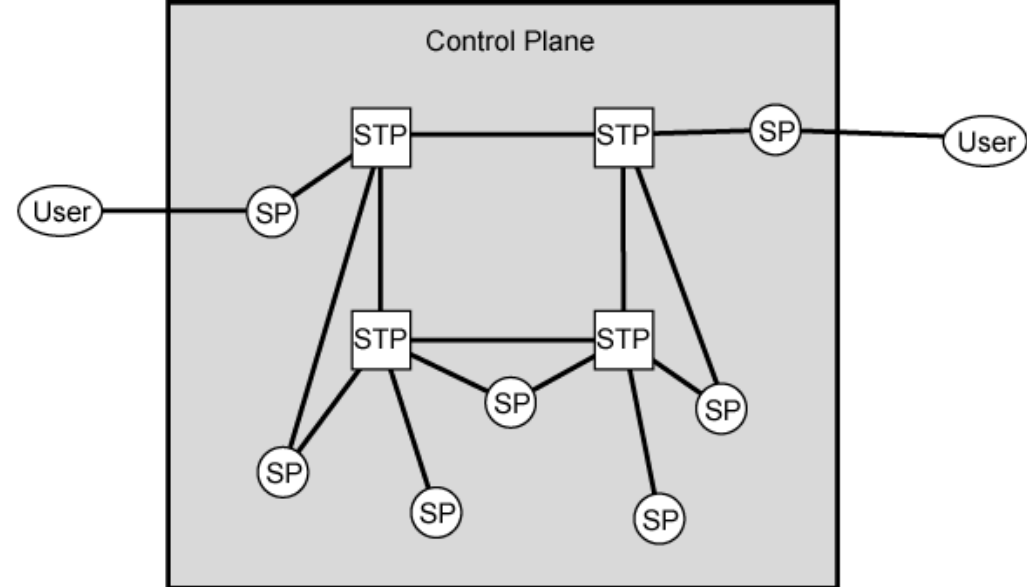
- SS7
- Common channel signaling scheme
- ISDN
- Optimized for 64k digital channel network
- Call control, remote control, management and maintenance
- Reliable means of transfer of info in sequence
- Will operate over analog and below 64k
- Point to point terrestrial and satellite links

SS7

Signaling Network Elements

- Signaling point (SP)
 - Any point in the network capable of handling SS7 control message
- Signal transfer point (STP)
 - A signaling point capable of routing control messages
- Control plane
 - Responsible for establishing and managing connections
- Information plane
 - Once a connection is set up, info is transferred in the information plane

Transfer Points



STP = Signaling transfer point
SP = Signaling point
TC = Transit center
LE = Local Exchange

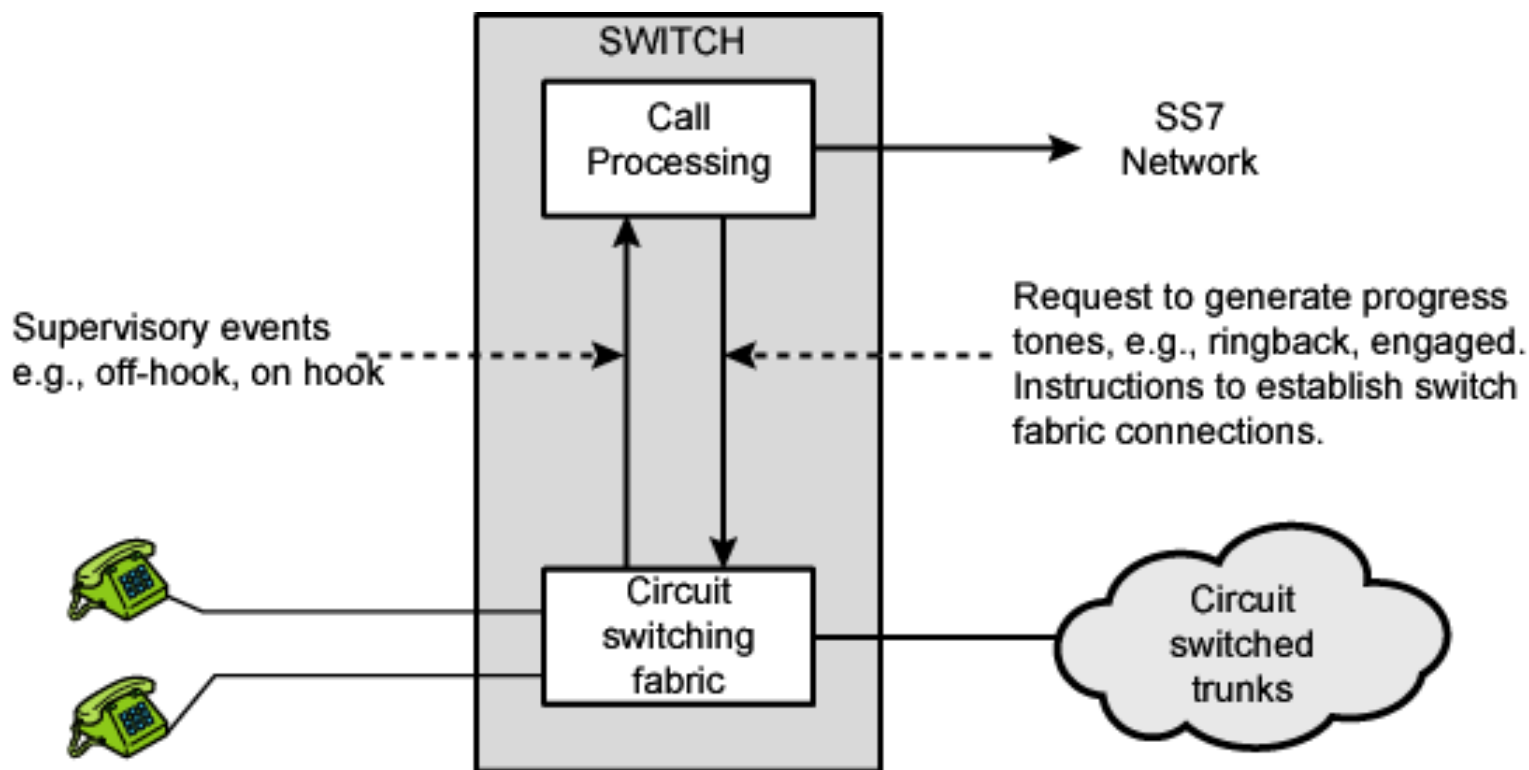
Signaling Network Structures

- STP capacities
 - Number of signaling links that can be handled
 - Message transfer time
 - Throughput capacity
- Network performance
 - Number of SPs
 - Signaling delays
- Availability and reliability
 - Ability of network to provide services in the face of STP failures

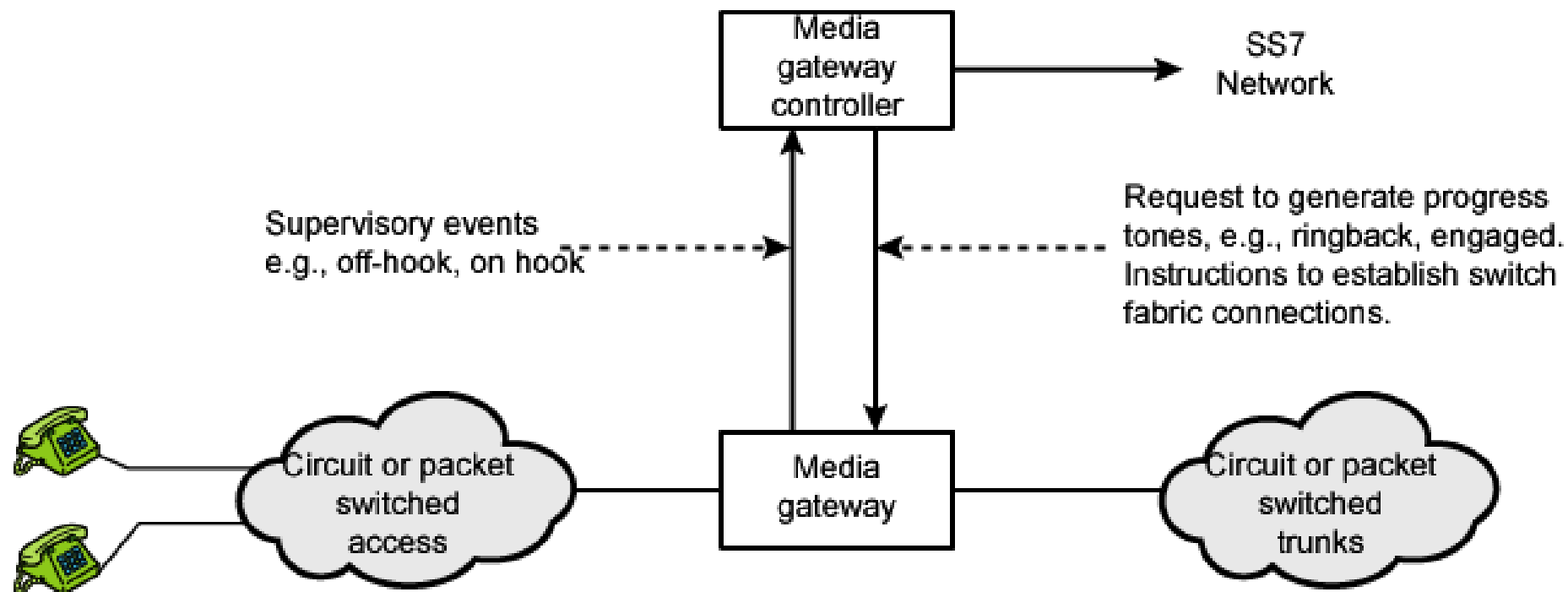
Softswitch Architecture

- General purpose computer running software to make it a smart phone switch
- Lower costs
- Greater functionality
 - Packetizing of digitized voice data
 - Allowing voice over IP
- Most complex part of telephone network switch is software controlling call process
 - Call routing
 - Call processing logic
 - Typically running on proprietary processor
- Separate call processing from hardware function of switch
- Physical switching done by media gateway
- Call processing done by media gateway controller

Traditional Circuit Switching



Softswitch



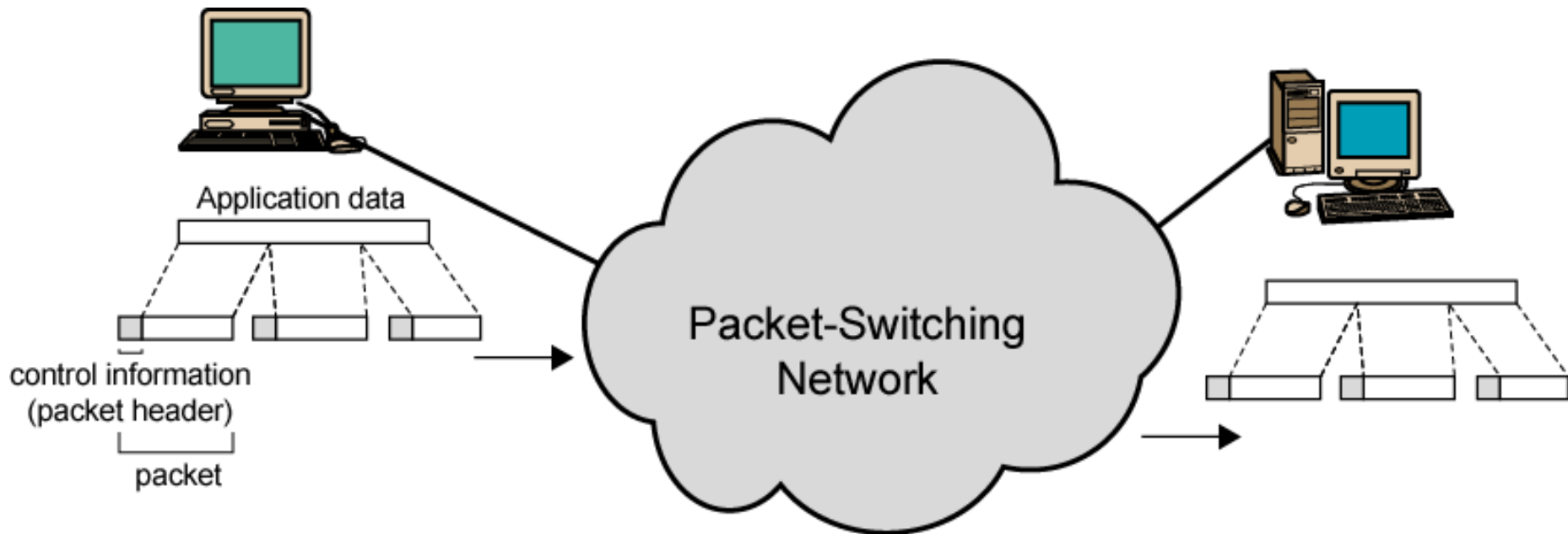
Packet Switching Principles

- Circuit switching designed for voice
 - Resources dedicated to a particular call
 - Much of the time a data connection is idle
 - Data rate is fixed
 - Both ends must operate at the same rate

Basic Operation

- Data transmitted in small packets
 - Typically 1000 octets
 - Longer messages split into series of packets
 - Each packet contains a portion of user data plus some control info
- Control info
 - Routing (addressing) info
- Packets are received, stored briefly (buffered) and past on to the next node
 - Store and forward

Use of Packets



Advantages

- Line efficiency
 - Single node to node link can be shared by many packets over time
 - Packets queued and transmitted as fast as possible
- Data rate conversion
 - Each station connects to the local node at its own speed
 - Nodes buffer data if required to equalize rates
- Packets are accepted even when network is busy
 - Delivery may slow down
- Priorities can be used

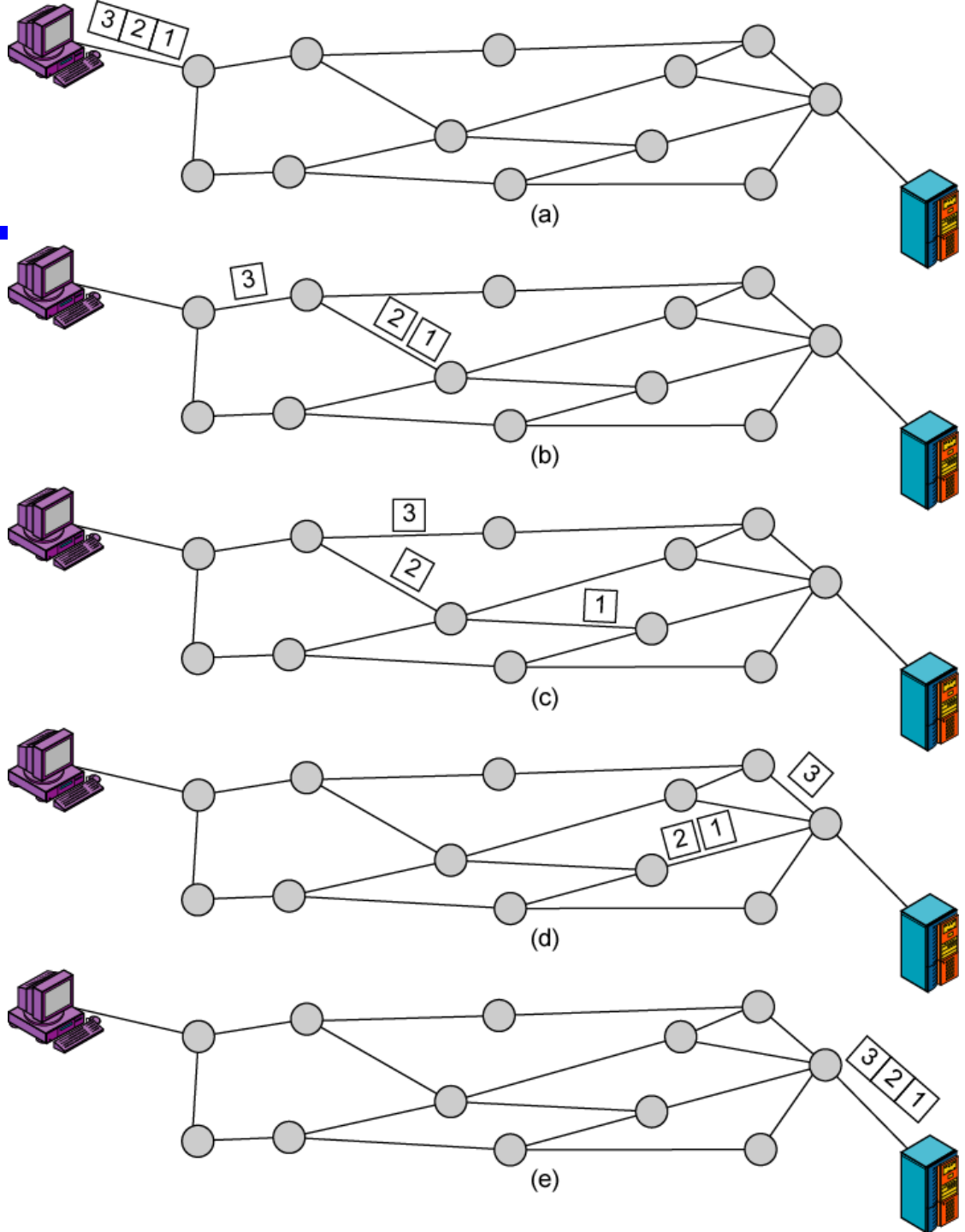
Switching Technique

- Station breaks long message into packets
- Packets sent one at a time to the network
- Packets handled in two ways
 - Datagram
 - Virtual circuit

Datagram

- Each packet treated independently
- Packets can take any practical route
- Packets may arrive out of order
- Packets may go missing
- Up to receiver to re-order packets and recover from missing packets

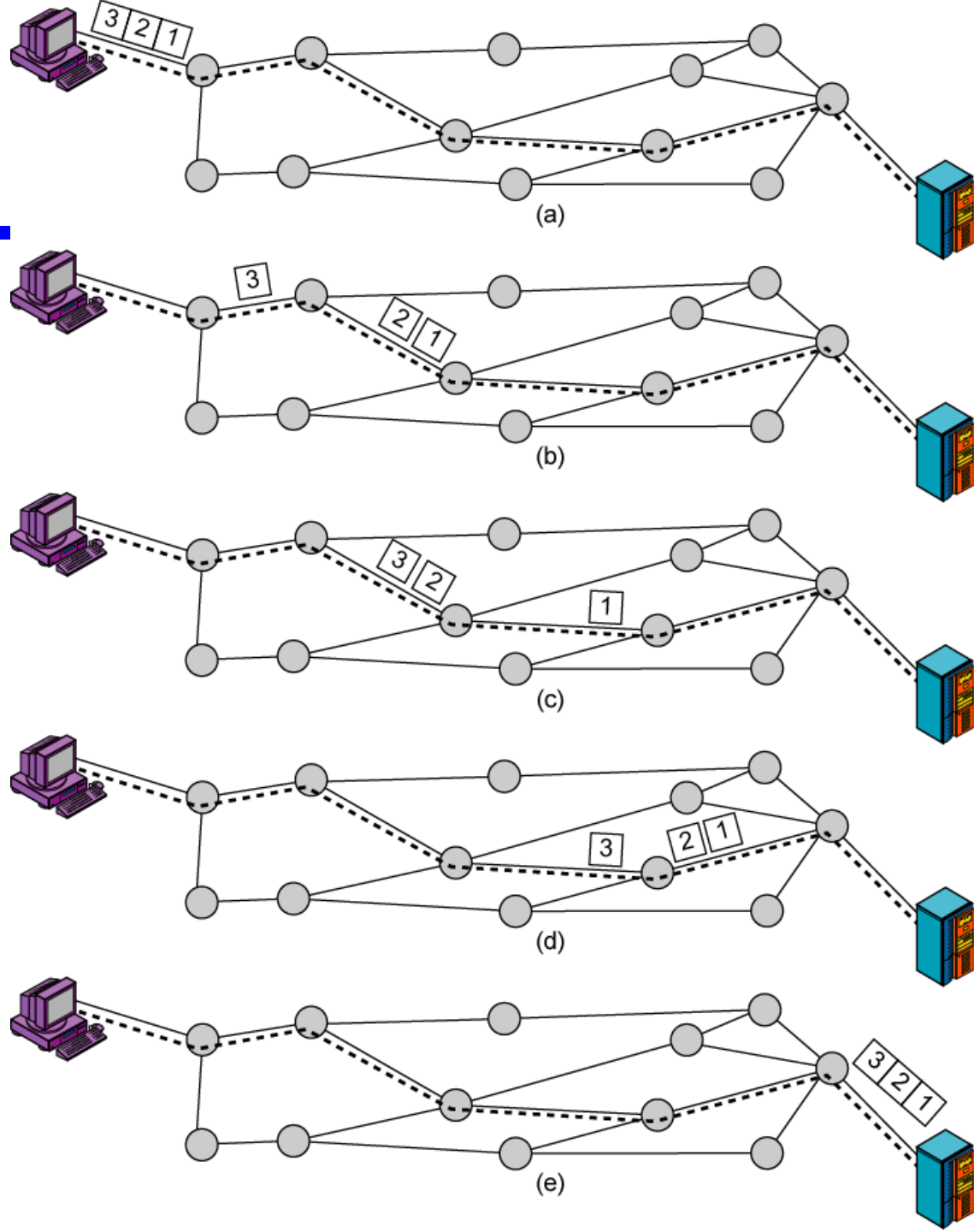
Datagram Diagram



Virtual Circuit

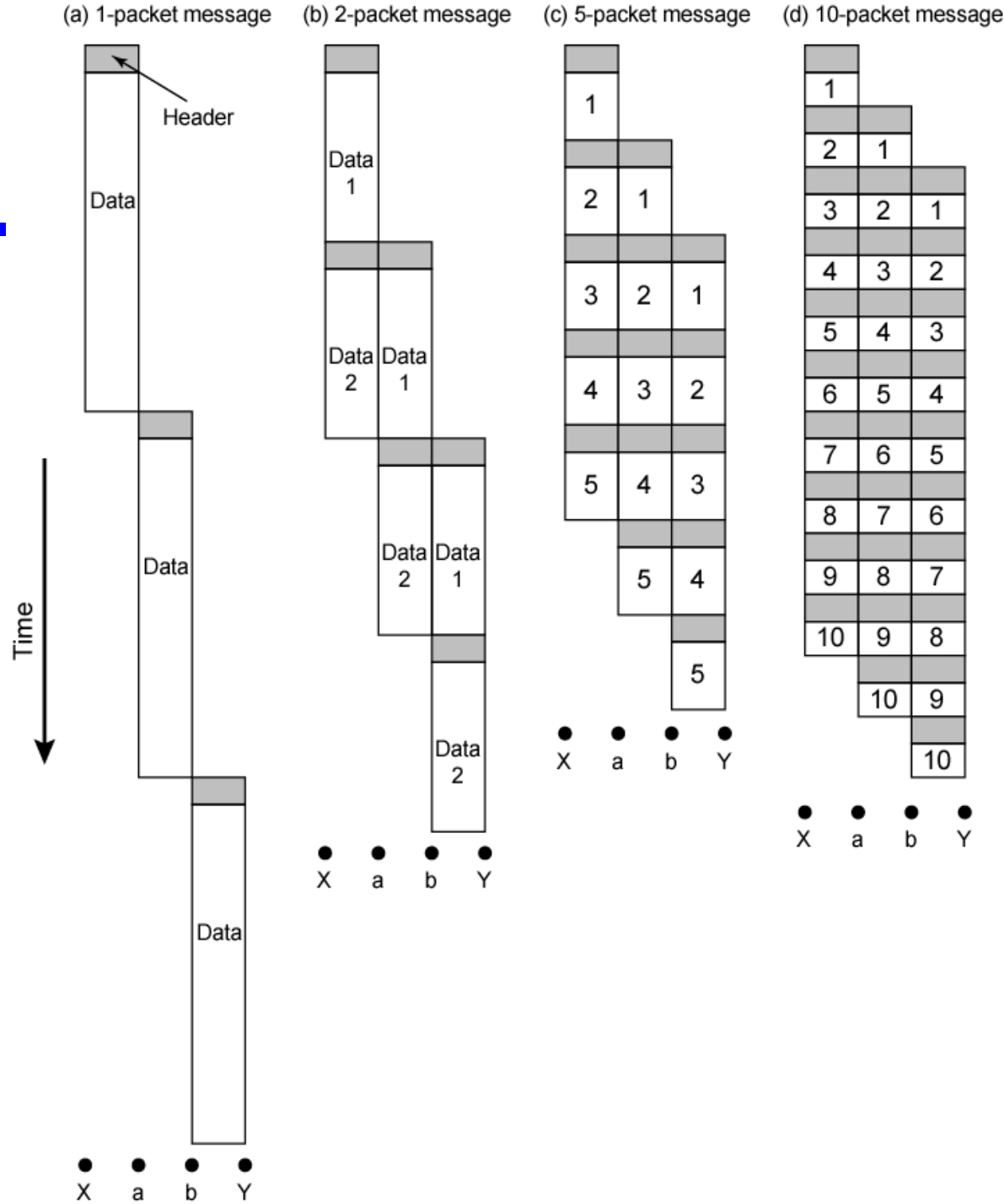
- Preplanned route established before any packets sent
- Call request and call accept packets establish connection (handshake)
- Each packet contains a virtual circuit identifier instead of destination address
- No routing decisions required for each packet
- Clear request to drop circuit
- Not a dedicated path

Virtual Circuit Diagram



Virtual Circuits v Datagram

- Virtual circuits
 - Network can provide sequencing and error control
 - Packets are forwarded more quickly
 - No routing decisions to make
 - Less reliable
 - Loss of a node loses all circuits through that node
- Datagram
 - No call setup phase
 - Better if few packets
 - More flexible
 - Routing can be used to avoid congested parts of the network

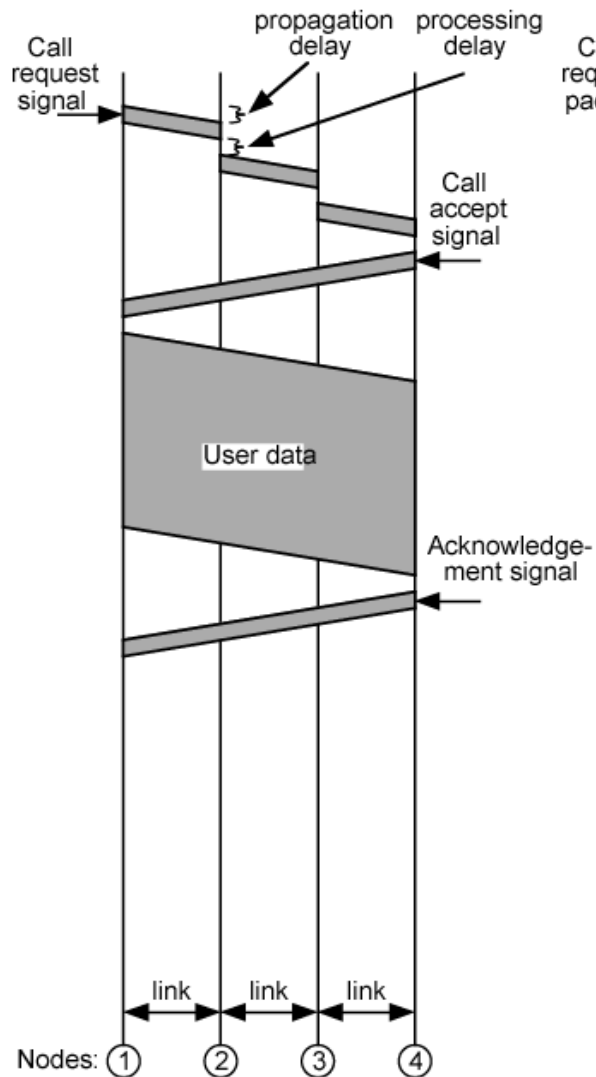


Circuit v Packet Switching

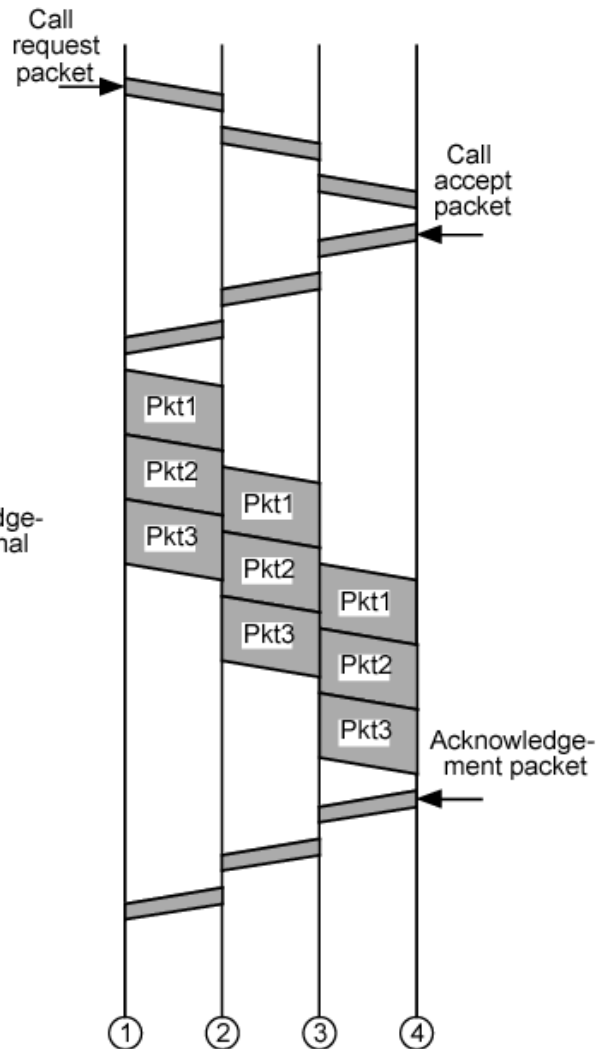
- Performance
 - Propagation delay
 - Transmission time
 - Node delay

Event Timing

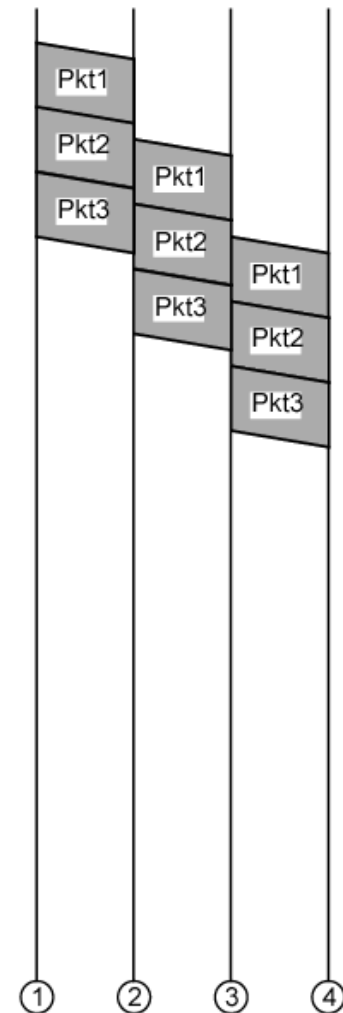
(a) Circuit switching



(b) Virtual circuit packet switching



(c) Datagram packet switching



X.25

- 1976
- Interface between host and packet switched network
- Almost universal on packet switched networks and packet switching in ISDN
- Defines three layers
 - Physical
 - Link
 - Packet

X.25 - Physical

- Interface between attached station and link to node
- Data terminal equipment DTE (user equipment)
- Data circuit terminating equipment DCE (node)
- Uses physical layer specification X.21
- Reliable transfer across physical link
- Sequence of frames

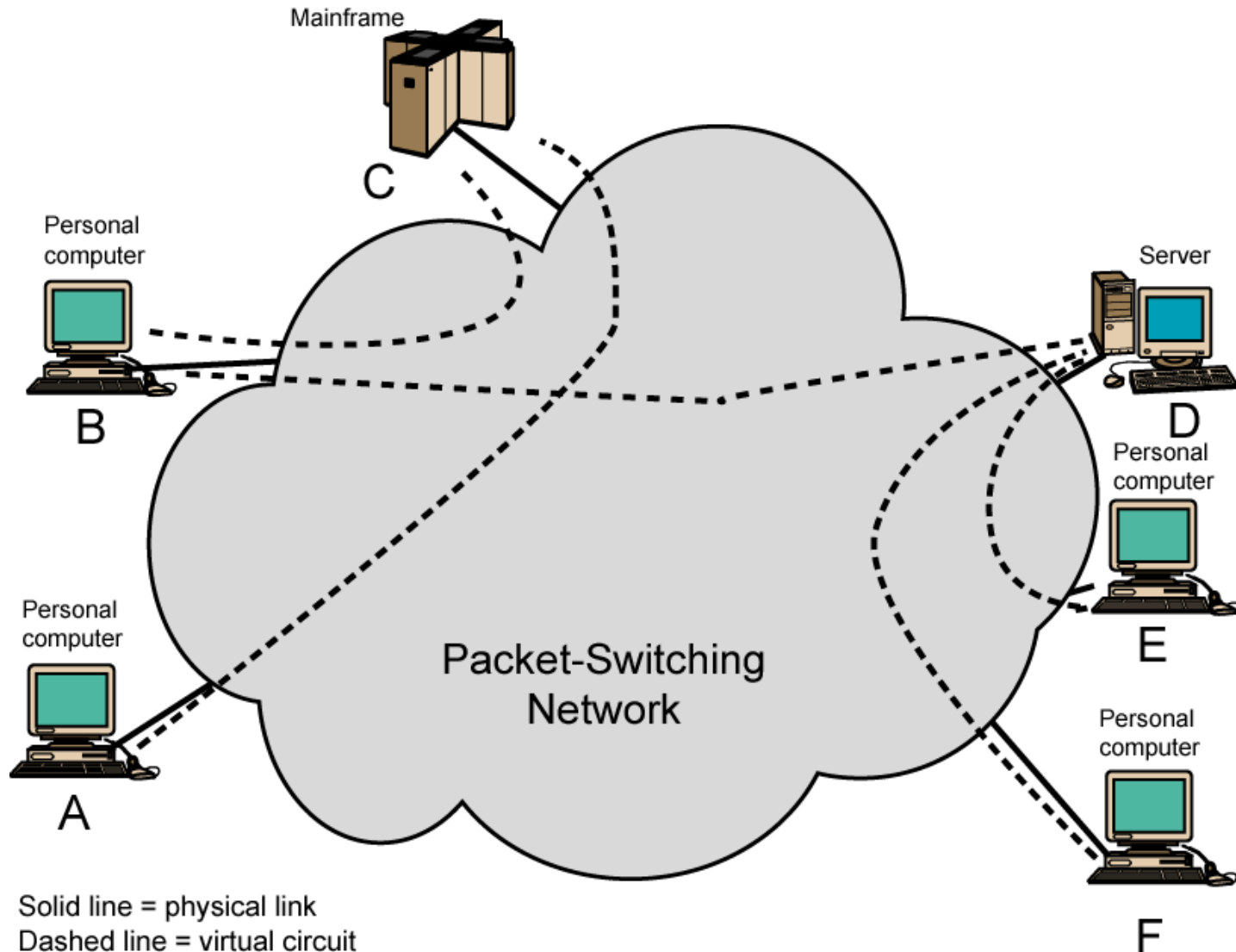
X.25 - Link

- Link Access Protocol Balanced (LAPB)
 - Subset of HDLC
 - see chapter 7

X.25 - Packet

- External virtual circuits
- Logical connections (virtual circuits) between subscribers

X.25 Use of Virtual Circuits



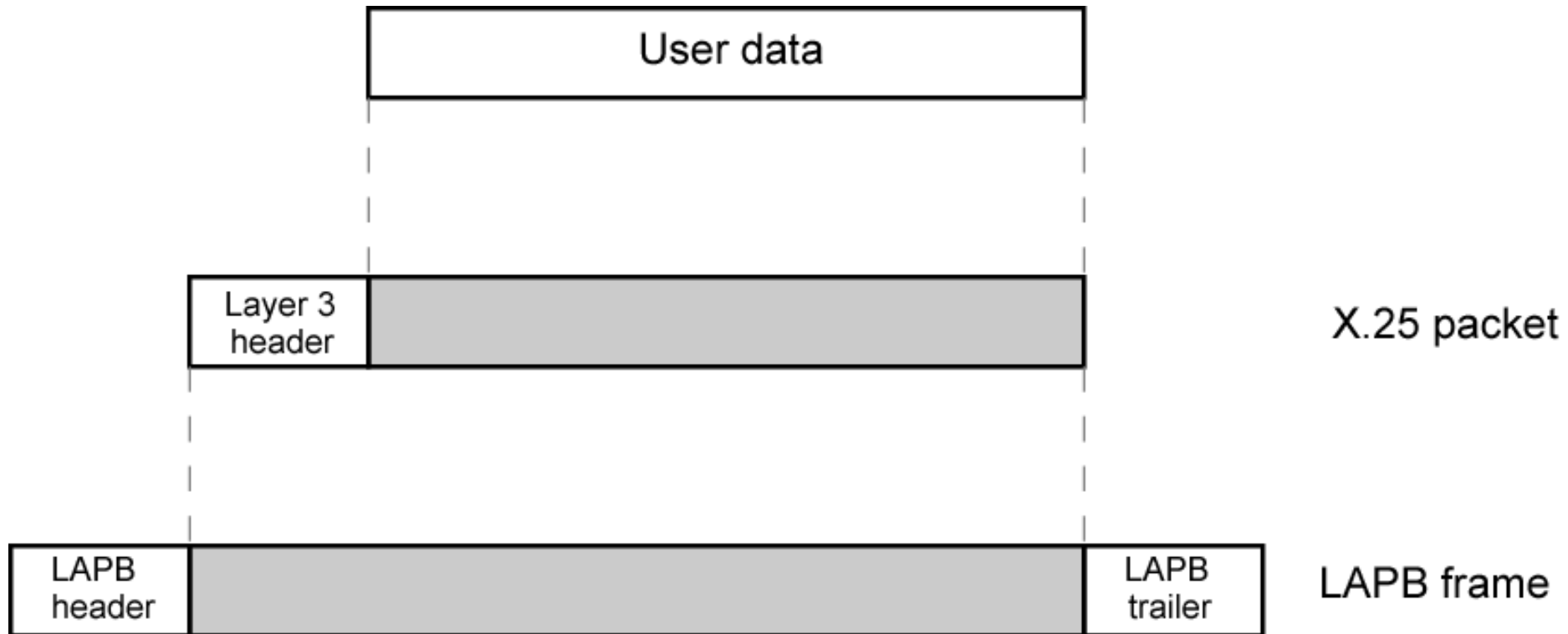
Virtual Circuit Service

- Logical connection between two stations
 - External virtual circuit
- Specific preplanned route through network
 - Internal virtual circuit
- Typically one to one relationship between external and internal virtual circuits
- Can employ X.25 with datagram style network
- External virtual circuits require logical channel
 - All data considered part of stream

X.25 Levels

- User data passes to X.25 level 3
- X.25 appends control information
 - Header
 - Identifies virtual circuit
 - Provides sequence numbers for flow and error control
- X.25 packet passed down to LAPB entity
- LAPB appends further control information

User Data and X.25 Protocol Control Information



Frame Relay

- Designed to be more efficient than X.25
- Developed before ATM
- Larger installed base than ATM
- ATM now of more interest on high speed networks

Frame Relay Background - X.25

- Call control packets, in band signaling
- Multiplexing of virtual circuits at layer 3
- Layer 2 and 3 include flow and error control
- Considerable overhead
- Not appropriate for modern digital systems with high reliability

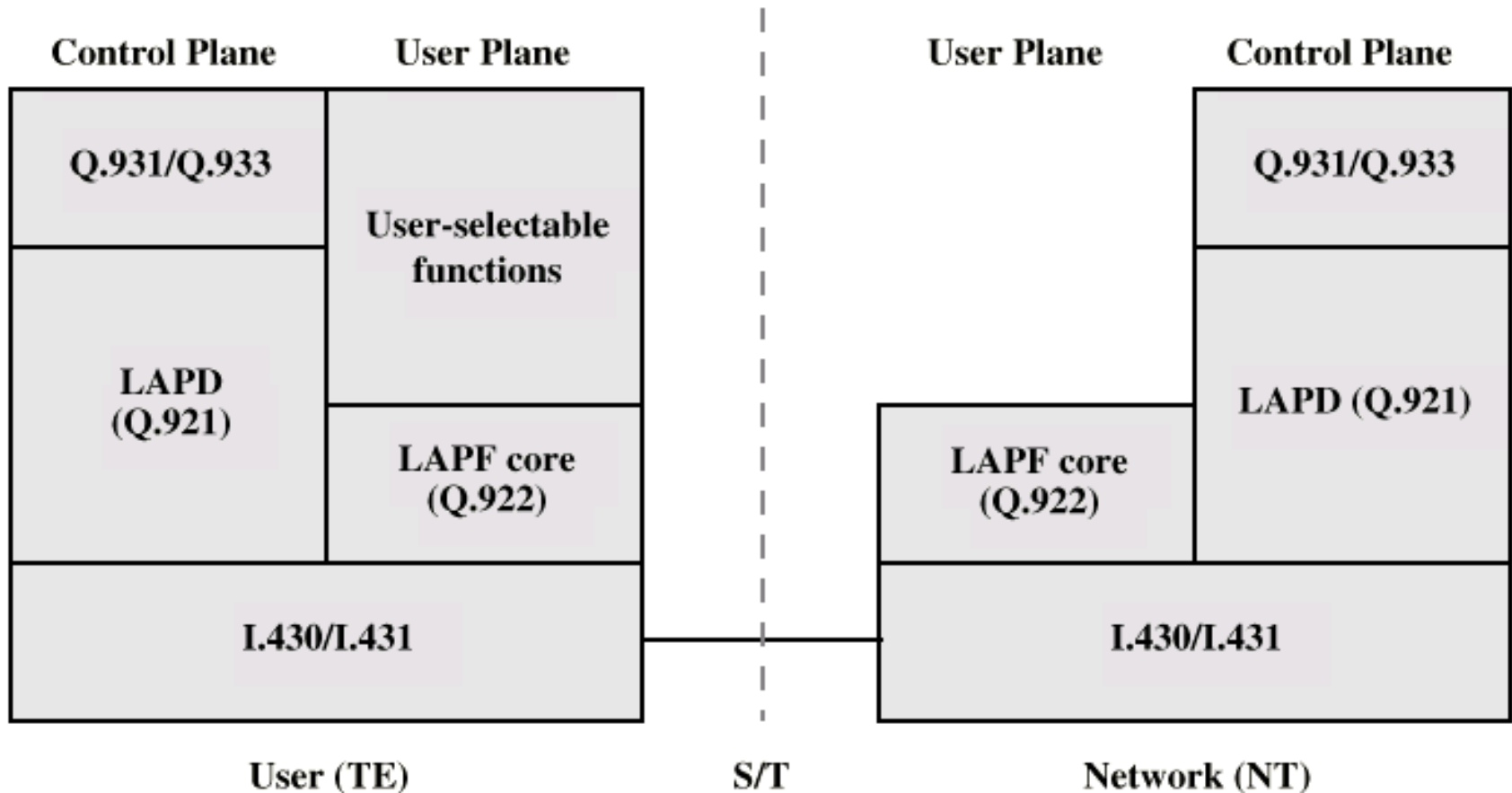
Frame Relay - Differences

- Call control carried in separate logical connection
- Multiplexing and switching at layer 2
 - Eliminates one layer of processing
- No hop by hop error or flow control
- End to end flow and error control (if used) are done by higher layer
- Single user data frame sent from source to destination and ACK (from higher layer) sent back

Advantages and Disadvantages

- Lost link by link error and flow control
 - Increased reliability makes this less of a problem
- Streamlined communications process
 - Lower delay
 - Higher throughput
- ITU-T recommend frame relay above 2Mbps

Protocol Architecture



Control Plane

- Between subscriber and network
- Separate logical channel used
 - Similar to common channel signaling for circuit switching services
- Data link layer
 - LAPD (Q.921)
 - Reliable data link control
 - Error and flow control
 - Between user (TE) and network (NT)
 - Used for exchange of Q.933 control signal messages

User Plane

- End to end functionality
- Transfer of info between ends
- LAPF (Link Access Procedure for Frame Mode Bearer Services) Q.922
 - Frame delimiting, alignment and transparency
 - Frame mux and demux using addressing field
 - Ensure frame is integral number of octets (zero bit insertion/extraction)
 - Ensure frame is neither too long nor short
 - Detection of transmission errors
 - Congestion control functions

User Data Transfer

- One frame type
 - User data
 - No control frame
- No inband signaling
- No sequence numbers
 - No flow nor error control

Required Reading

- Stallings Chapter 10
- ITU-T web site
- Telephone company web sites (not much technical info - mostly marketing)
- X.25 info from ITU-T web site
- Frame Relay forum